

A new Arenig trilobite fauna from the Bangor area, North Wales

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SYNOPSIS. A diachronous sandstone unit forms the local base of the Arenig sequence throughout north Wales. Various names have been given to this unit, and the Maes y Geirchen Sandstone Member of the Nant Ffrancon Formation is recommended for the Bangor area. Three exposures of the Maes y Geirchen Member are described and the unit is interpreted as a shallow marine deposit, thickening to the south. A bedded sandstone sequence at the base accounts for most of the thickening and is interpreted as a sand lobe deposited by storm processes in deeper water.

The fauna comprises trilobites, brachiopods and bivalves, and the five trilobite species are described in this paper. The fossils are predominantly from the bedded sandstones and were apparently transported by storm currents, with some winnowed lags developing under waning conditions. Rare specimens from the thinner, more rudaceous deposits to the north are of the same fauna.

All but one of the trilobite species are new and *Asaphellus* cf. *graffi* (Thoral) provides little age control. Three new species are described: *Annamitella sinesulcata*, *Neseuretus caerhunensis* and *Calymenella preboiselli*. The presence of *Azygograptus eivionicus* Elles in overlying flaggy sandstone is thought to indicate a late Moridunian to early Whitlandian age. The generic composition of the fauna suggests comparison with that from the Carmel Formation of central Anglesey, probably Fennian in age. The *Neseuretus* species of the Bangor and Anglesey faunas also show greater similarity to each other than to other members of the genus. *N. monensis* (Shirley) is redescribed. This may indicate a different lineage peculiar to the exterior margin of the Welsh Basin but Anglesey can no longer be considered as faunally distinct from the mainland.

INTRODUCTION

Throughout north Wales a shallow-water sandstone unit occurs at the base of the Arenig Series. The time of onset of deposition and magnitude of the underlying unconformity vary between areas, and these areas are thought to define

separate, fault-bounded, structural blocks, active in the Lower Palaeozoic (Beckly 1987).

The only fossils hitherto described from this sandstone unit are the trilobite and brachiopod fauna of the Carmel Formation in central Anglesey (Bates 1968, Neuman & Bates 1978). The present paper describes a new trilobite fauna recently collected from the sandstone unit at the base of the Arenig sequence in the Bangor area. The *Neseuretus* and *Annamitella*

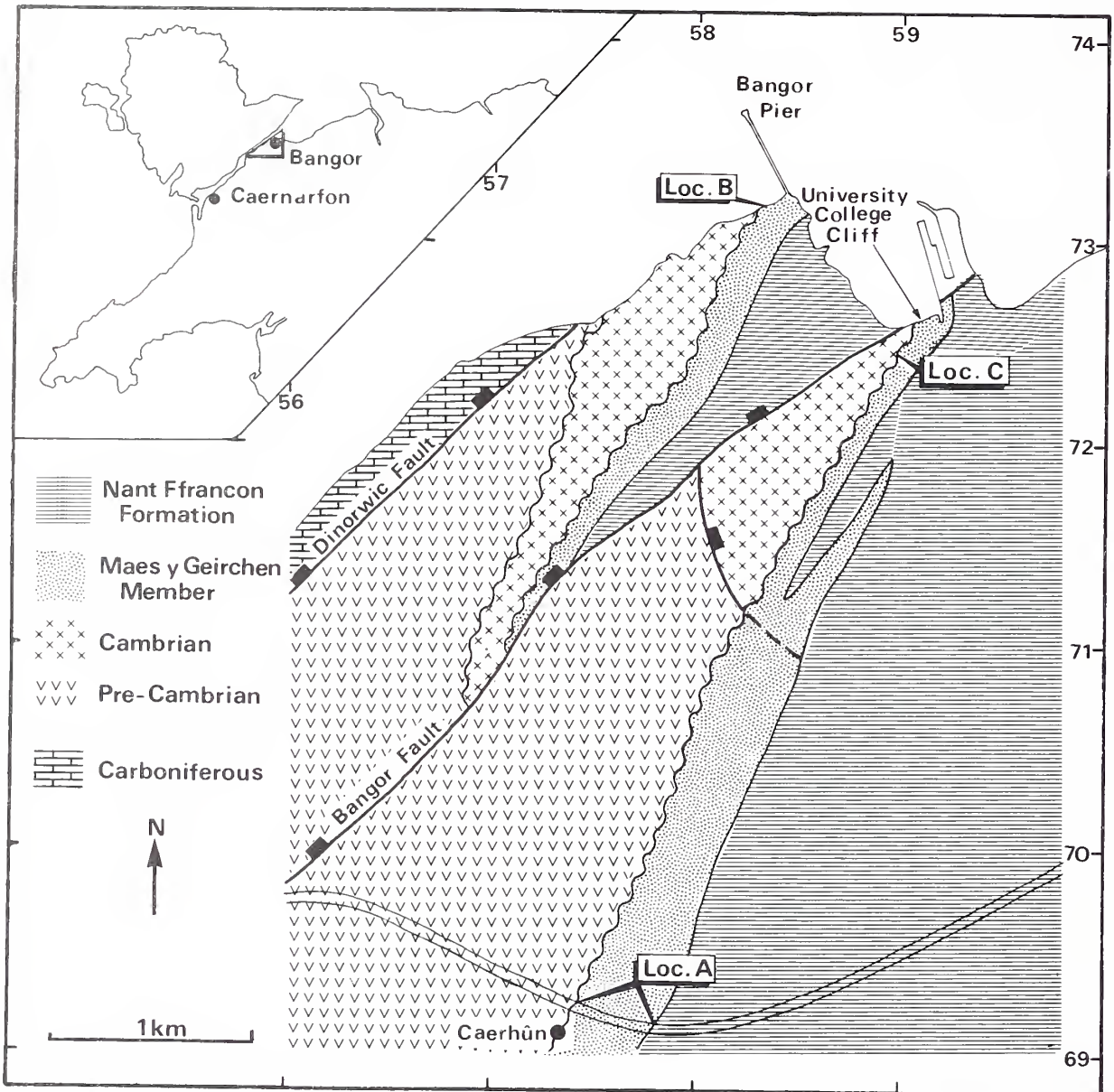


Fig. 1 Simplified geological map of the Bangor area. Loc. A, cutting on A5 near Caerhŷn; Loc. B, foreshore section west of Bangor Pier; Loc. C, inland from Penrhyn Dock.

species display features that suggest a comparison with the Anglesey fauna. However, the overall generic composition is typical of later shallow-marine facies around Gondwana, and notably *Calymenella* is recorded for the first time below the Caradoc. *Neseuretus monensis* (Shirley) is also redescribed (p. 13). Specimens are deposited in the Dept of Palaeontology, British Museum (Natural History), apart from the material of *N. monensis* which is held by the British Geological Survey.

Localities

The basal unconformity is exposed in three places near Bangor (see Fig. 1):

- (A) the cutting on the A5 just east of the flyover at Caerhŷn (NGR SH 576692) (Fig. 2),
- (B) the cliff section approx. 100 m west of Bangor Pier (SH 583732) (Figs 3, 4), and
- (C) a small exposure at the foot of the wood 150 m inland

from the University College Cliff section figured by Greenly (1944: 80; fig. 2) (SH 5901 7247) (Fig. 5).

Apart from a single cranium of each of *Calymenella preboiselli* sp. nov. and *Neseuretus* indet. from Loc. B, all material came from Loc. A. The majority of material was collected during road construction and much of it came from loose blocks taken from the cutting.

Lithostratigraphy

A single lithostratigraphic terminology has been used for the Arenig Series over the entire Bangor Sheet (Howells *et al.* 1985), though the type localities for these units lie to the east of the Aber-Dinlle fault. Such a uniform view is questionable. There is evidence that the Aber-Dinlle fault was active during the Lower Palaeozoic (Webb 1983), and the basal sandstone in the Bangor area is more similar to the Carmel Formation of central Anglesey than to the type Graianog Sandstone

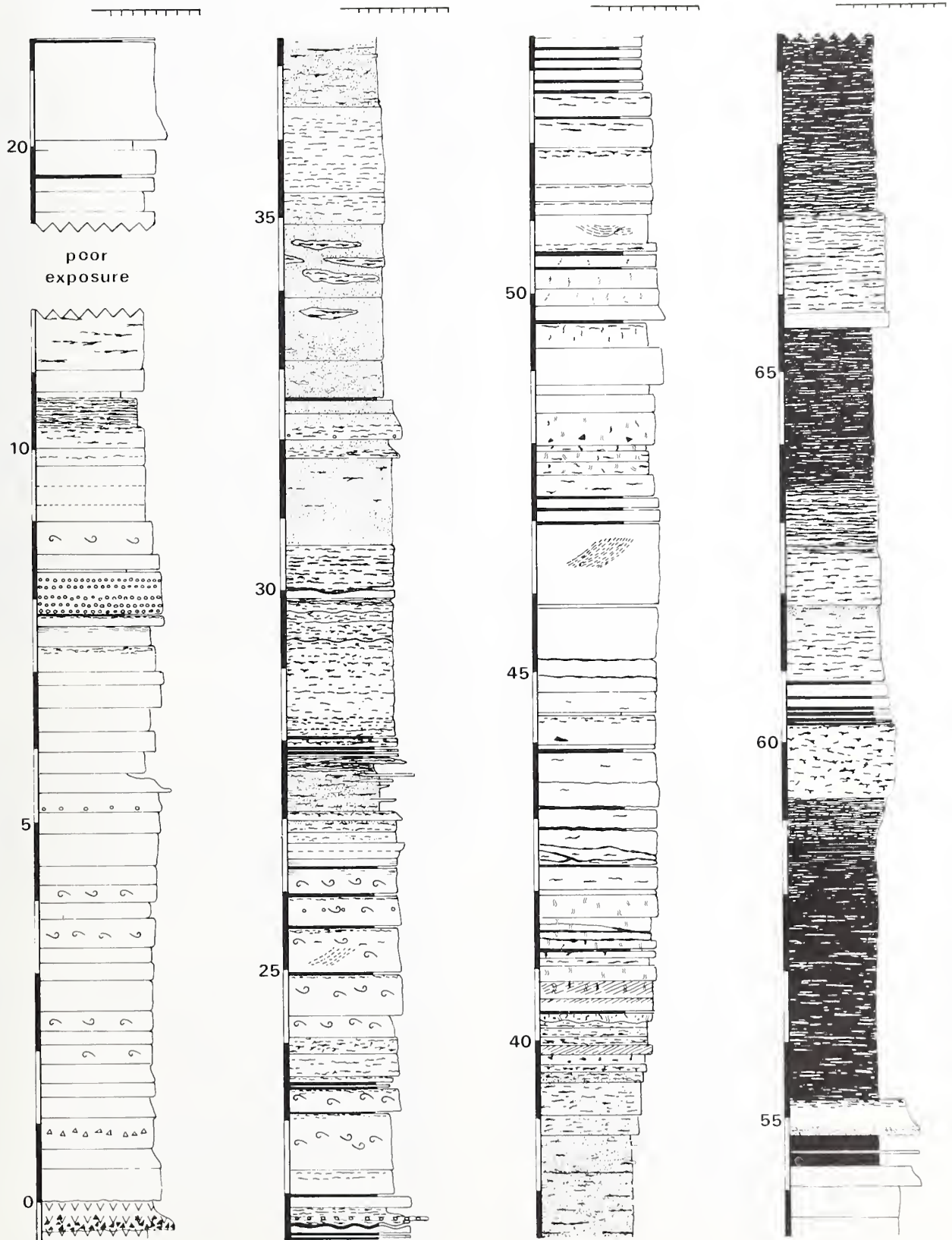


Fig. 2 Sedimentary log of the Maes y Geirchen Sandstone Member in cutting on A5 near Caerhŷn. Key given with Fig. 5, p. 7.

Member. However, no fewer than four other names have been used for the intervening exposures of basal Arenig sandstone on Anglesey (Bates 1972) and unless all are placed in a single lithostratigraphic unit there appears no alternative but to have a separate name in the Bangor area. It is therefore recommended that the name Maes y Geirhen Quartzite Member (Reedman *et al.* 1983) be changed to the Maes y Geirhen Sandstone Member and extended to include the entire basal sandstone sequence. The overlying siltstone sequences are more difficult to characterize and have not generally been named. For this reason the use of the name Nant Ffraneon Formation is tentatively retained.

Mapping by the Geological Survey (Howells *et al.* 1985) shows the magnitude of the sub-Arenig unconformity to increase from north to south (see Fig. 1); the sandstone on the Bangor foreshore rests on the Cambrian Llanberis Slate Formation whilst the sequence exposed on the A5 rests on the Arvonian Minffordd Formation.

SEDIMENTOLOGY

Description of sedimentary sequences

Cutting on A5 near Caerhûn. (Loc. A)

A log through the sandstone unit is shown in Fig. 2.

The top of the underlying Minffordd Formation (Reedman *et al.* 1984) is dominated by gravel grade intraformational breccia associated with lithic sandstone, both composed entirely of Arvonian detritus. The base of the Maes y Geirhen Member, and hence of the Arenig, is marked by the first appearance of a medium grade micaceous quartzose sandstone with no evidence of any coarser quartzose material, though some angular fragments of the underlying Arvonian do occur. Coarser, gravel grade, quartz elasts come in about 5 m above the base, and even then are relatively sparse. Pebble grade extraformational elasts are absent from the entire sequence. The Maes y Geirhen Member may here be divided into three (see Fig. 2).

1: Lower Clean Sandstone Unit (Fig. 2, 0–27 m). This is approximately 27 m thick and is dominated by sandstone very similar to that seen at the base, i.e. although quartzose, it contains a very high proportion of mica. This sandstone is well-bedded, but monotonous, showing few sedimentary structures. It is hard and mostly grey in colour, though occasional rusty weathering is present. After the incoming of the first coarser material, about 5 m above the base, the sequence is somewhat more variable, though an area of poor exposure, 12 to 19 m above the base, is dominated by a lithology very similar to that which forms the basal 7 m, possibly with slightly greater rusty colouration. Just above this area are 5 m of slightly more muddy and rusty weathering sandstone, overlying a fairly massive coarse bed, which contain abundant fossil material. Most of the loose blocks from which fossils were collected probably came from this horizon. Scattered fossils do occur below this, as indicated on the section, but they are rare.

2: Muddy Sandstone Unit (Fig. 2, 27–41m). Though sandstone is still dominant, in this part of the sequence there is significantly more silty mudstone present than in the sandstone units above or below. The mud flasers are often very irregular in shape, and this has been increased by

bioturbation, which for two reasons is also thought to be responsible for the more homogeneous muddy sandstone. First, occurring in the muddy sandstone are patches of cleaner sandstone within which mud flasers can be recognized, though they are apparently absent from the surrounding lithology. These patches probably represent regions of sediment which have escaped bioturbation. Second, two beds are present which show mud flasers in the cleaner sand of the lower half but are a more homogeneous muddy sand in the upper. This would be compatible with biological reworking of the top of a single depositional package.

3: Upper Clean Sandstone Unit (Fig. 2, 41–55m). This differs from the Lower Clean Sandstone Unit in being paler, compositionally closer to quartzite and showing evidence of cross-bedding. The contact with the underlying muddy sandstone unit is somewhat gradational. The clearest examples of cross-bedding are tabular cosets of planar cross-bedding occupying the bed thickness, but trough cross-bedding may also be present. The combination of large scale cross-bedding with more mature sediment composition suggests a higher energy environment than that in which the lower part of the sequence was deposited. Other differences from the Lower Clean Sandstone Unit include a generally greater grain size, and the presence of mud elasts up to 8 cm in length. Some bioturbation is indicated by vertical muddy streaks but many of the beds are massive and featureless.

The transition into the overlying shale-dominated sequence is sharp and a rudaceous bed is associated with the junction. A gravel grade fraction, distinctly coarser than the lithologies below, is dominant, but the matrix is silty mudstone. The concentration of coarser material probably has a genetic association with the change in facies and may represent some form of lag deposit.

Foreshore section west of Bangor pier. (Loc. B)

A continuous section cannot be measured here because of dissection by faults, particularly those parallel to the cliff face (see Fig. 3). The only part of the section that can be accurately placed on the larger scale is that directly overlying the basal unconformity. However, this indicates that as little as 7 m of thick-bedded sandstone is present before argillaceous, flaggy sandstone becomes prevalent. Thicker sandstone beds are present within this facies but there is no good evidence that they become dominant again.

The sandstone beds directly overlying the unconformity are different from those in the A5 section, with generally coarser lithologies and in having obvious lenticular units. There are two main types of coarse lithology present: fairly well sorted coarse quartzose sandstones occasionally grading towards gravel grade, and poorly sorted paraconglomerates.

It is these conglomerates that have yielded the small number of fossils found in this section. The matrix of these beds is a medium-grained micaceous and quartzose sandstone. The rudaceous component is polymict, angular to subrounded, and ranges up to small pebble grade. The dominant lithologies are quartzite and fragments of the underlying volcanics. The rudaceous component is generally fairly diffusely scattered in the beds, though not infrequently drapes low-angle foresets. Cross bedding is also apparent in the cleaner, well sorted sandstones beds.

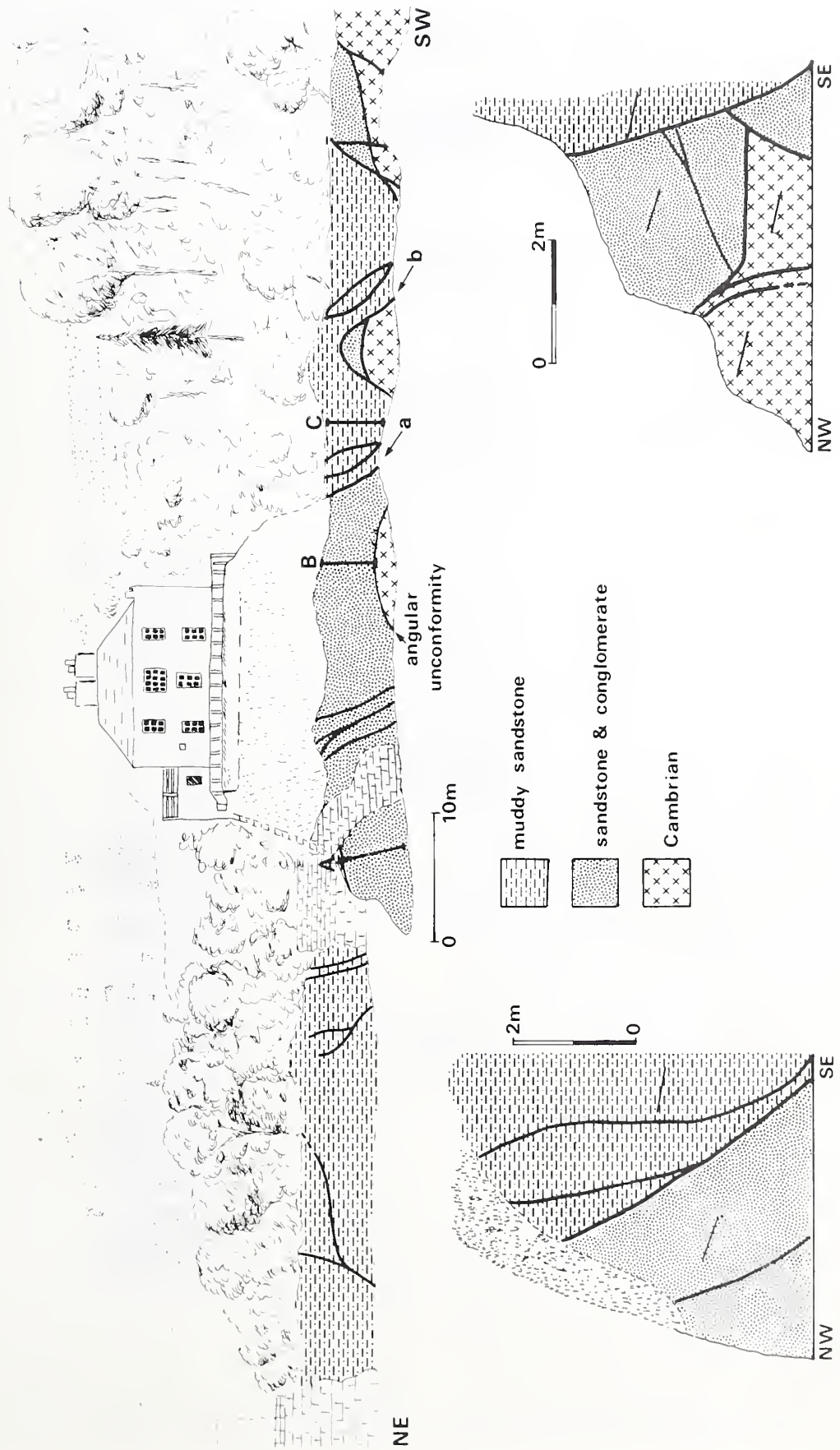


Fig. 3 Sketch of cliff section west of Bangor Pier.

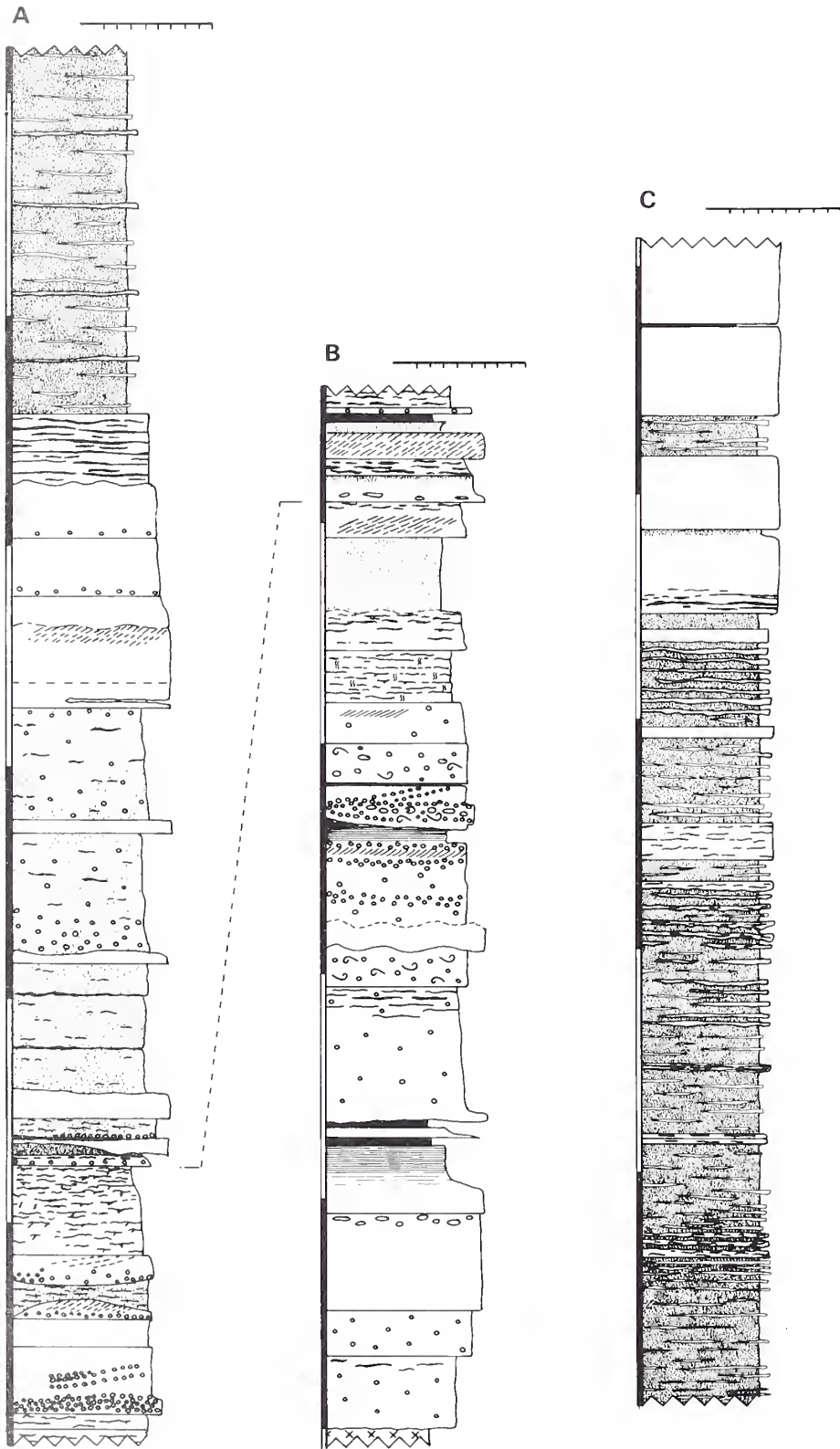


Fig. 4 Sedimentary logs of the Maes y Geirchen Sandstone Member west of Bangor Pier. Positions of sections are shown in Fig. 3. Possible correlation between sections A and B is indicated. Key given with Fig. 5, opposite.

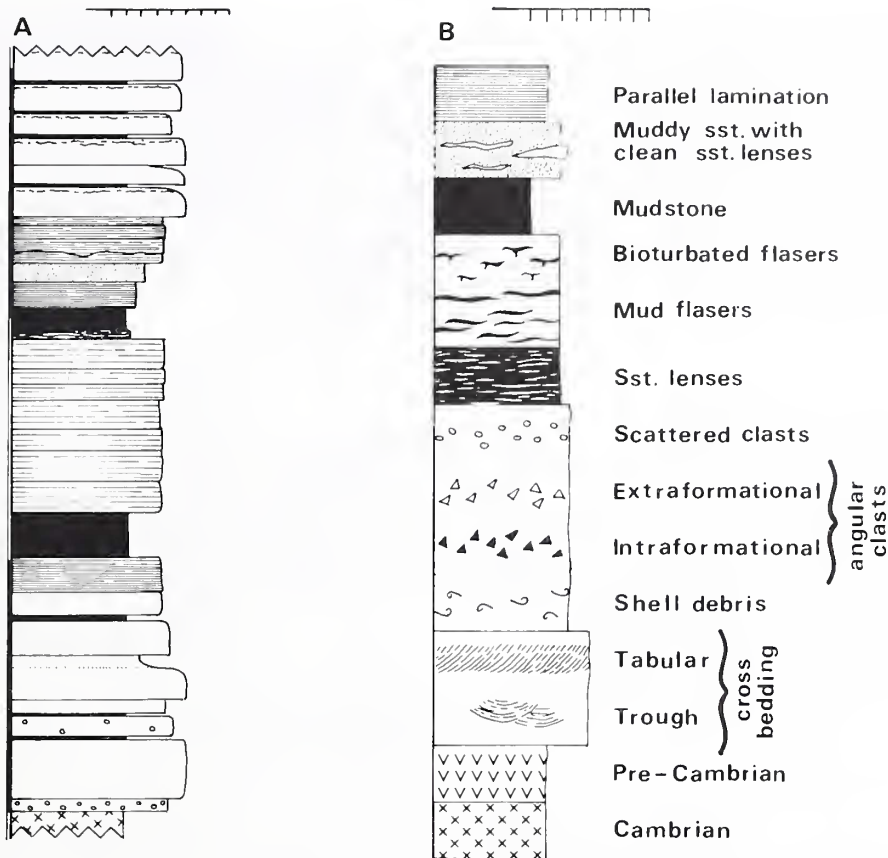


Fig. 5 A: Sedimentary log of the base of the Maes y Geirchen Sandstone Member inland from Penrhyn dock. B: Key to symbols used in sedimentary logs. Clean sandstones unshaded. At top, grain size scale from left to right: clay; silt; fine, medium, coarse sand; gravel; pebble; cobble; boulder. Vertical bars represent 1 m in all sections.

Inland from University College Cliff, Bangor. (Loc. C)

Only a very short section is exposed above the unconformity and this has not yielded any fossils. The coarse nature of the base is comparable to that west of Bangor Pier. This serves to confirm that the variation in the base is primarily north-south rather than influenced by the Bangor Fault.

Taphonomy

On the Bangor foreshore the few fossils that have been found appear to have become entrained with the rest of the coarse clastic fraction, and with it undergone relatively little sorting. This is in marked contrast to the section on the A5, where there is considerable sorting in the absence of any significant coarse clastic material.

Three main faunal elements are present in the A5 cutting: trilobites, brachiopods and bivalves. The first and last appear to be almost mutually exclusive with distinct modes of occurrence, whilst brachiopods occur with both and are occasionally dominant, usually when fossil material is relatively sparsely scattered.

The trilobite material is totally disarticulated. Though some fragments appear broken, there is no evidence of significant abrasion, e.g. genal spines still run to a point. The most common mode of occurrence is in beds that are very slightly graded from medium-coarse to medium sandstone which is of the typical quartz-mica type. Towards the tops of the beds there is some evidence of mud flasers. The trilobite material occurs in the top half of the beds predominantly

parallel to bedding, its first appearance often marked by a concentrated band. Above this the fragments are generally more scattered, though concentrations can occur at virtually any point in the upper half, sometimes forming a nearly continuous surface of fragments. The absence of shell material from the lower half is fairly consistent.

Bivalves occur as distinct bands of both single and articulated valves within a sandstone bed and are often associated with gravel clasts of a comparable size. Such bands can be quite widely spaced or concentrated into a 'roach'-like lithology. Occasional scattered specimens do occur between such bands but represent an insignificant proportion of the total number of specimens present.

Depositional Environment

In common with the sandstone units found at the local base of the Arenig in the rest of north Wales, the basal Arenig sandstone unit of the Caernarfon-Bangor area was deposited in a shallow-marine environment.

The presence of trilobites of the *Neseuretus* community suggests a shallow marine environment (Fortey & Morris 1982), and although this material is transported the presence of *Azygograptus* in the overlying 'flaggy' sandstones at Bangor (Beckly 1985) indicates that it has not been carried into a significantly deeper environment.

The lateral variation between the A5 section and the Bangor foreshore suggests shallowing, and a source area, to the north (see Fig. 6). The coarse units of the foreshore

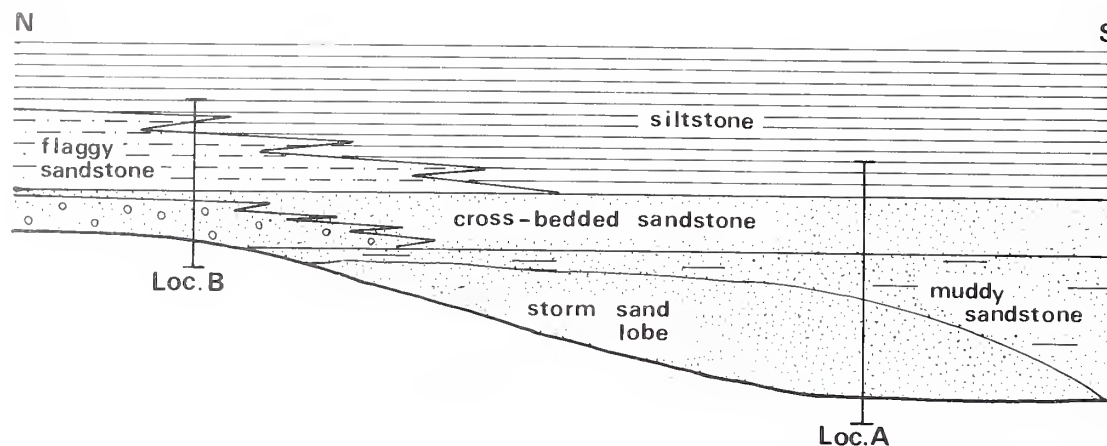


Fig. 6 Schematic depositional model for the Maes y Geirchen Sandstone Member in the Bangor area.

section are similar to the shallow-marine pebbly sandstones illustrated from the Lower Carboniferous of Morocco (Graham 1982). The poorly sorted nature of these deposits is not compatible with wave reworking and therefore it is likely that even these were deposited below normal wave-base.

As described, the A5 section broadly divides into three units. The absence of a basal coarse unit and the higher energy features of the Upper Clean Sandstone Unit suggests an overall shallowing during deposition, probably by gradual infilling of a basin. The Lower Clean Sandstone Unit of the A5 section is thought to represent a rapidly deposited sand lobe, probably storm-generated, with the muddy sandstone unit above indicating a quieter abandonment environment, with sandstone deposition more intermittent. The sandstone beds are comparable to, though thicker than, the type 1 sandstones recognized from the Caradocian of Shropshire (Brenchley & Newall 1982). The fossil material does not form basal coquinas (cf. Kreissa 1981) and this probably indicates that it has been transported rather than winnowed into a lag, the latter only being suggested by the bivalve bands. The concentration of the shell material within the top half of the beds suggests waning of a flow that was initially capable of moving the fragments. The concentrated bands probably reflect brief periods of winnowing in the later stages of a prolonged storm.

The features of the Upper Clean Sandstone Unit suggest relatively shallow water deposition, probably close to normal wave base. This represents a progradation of the basal facies seen at Bangor. The sharp transition between the top of this unit and the overlying shale-dominated sequence probably reflects a second, quite rapid, deepening of the basin.

SYSTEMATIC DESCRIPTIONS

Terminology follows that of the *Treatise on Invertebrate Paleontology*, O, Arthropoda 1 (Harrington, Moore & Stubblefield, in Moore 1959). 'Glabella' is usually understood to include the occipital ring. Systematic order is by family as they appear in the *Treatise* (Moore 1959).

Family LEIOSTEGIIDAE Bradley, 1925

Genus ANNAMITELLA Mansuy, 1920

TYPE SPECIES. *Annamitella asiatica* Mansuy, 1920.

DISCUSSION. In the review of this genus by Fortey & Shergold (1984: 323) a number of genera were considered to be junior synonyms. Though these included *Monella*, the type species of which is *A. perplexa* (Bates 1968) from Anglesey, it was suggested that this genus may be a junior synonym of a possibly separate genus *Proetiella* Harrington & Leanza (1957: fig. 59, 3-7), based on the presence of a 3P glabellar furrow.

The material described below is similar to *A. perplexa* in having a flat pygidial border, and anterior cranial border not incorporated into the glabella. Neither of these characters is shared by *Proetiella* and therefore this grouping does not seem valid. *A. guizhousensis* Yin & Li (1978: pl. 183, figs 4-7) shares the cranial characters of *A. perplexa* in having a 3P furrow and separate anterior border, but has a pygidium typical of other members of *Annamitella*. Therefore if *Monella* is to be recognized as a separate genus, the distinguishing characters must be those of the pygidium: flat border and less prominent development of axial rings and pleural furrows. However, for the present the two north Wales species are retained in *Annamitella*.

Annamitella sinesulcata sp. nov.

Figs 7a-f; 8b

DIAGNOSIS. Effaced species of *Annamitella* with no evidence of lateral glabellar furrows. Weakly defined anterior border present. Pygidium with fairly broad, flat, sloping border.

HOLOTYPE. It19829, internal mould of solitary cranium.

MATERIAL. Cranidia: It19803, It19818, It19829, It19858. Pygidia: It19817, It19837, It19840.

LOCALITY. Known only from A5 cutting at Caerhŷn.

NAME. From the Latin *sine* (without); *sulcus* (furrow)

DESCRIPTION. Most material known from internal moulds.

Cranidium: Rectangular glabella defined by broad, deep axial furrows that are subparallel posteriorly but diverge anteriorly, giving glabellar sides a concave form. Transverse

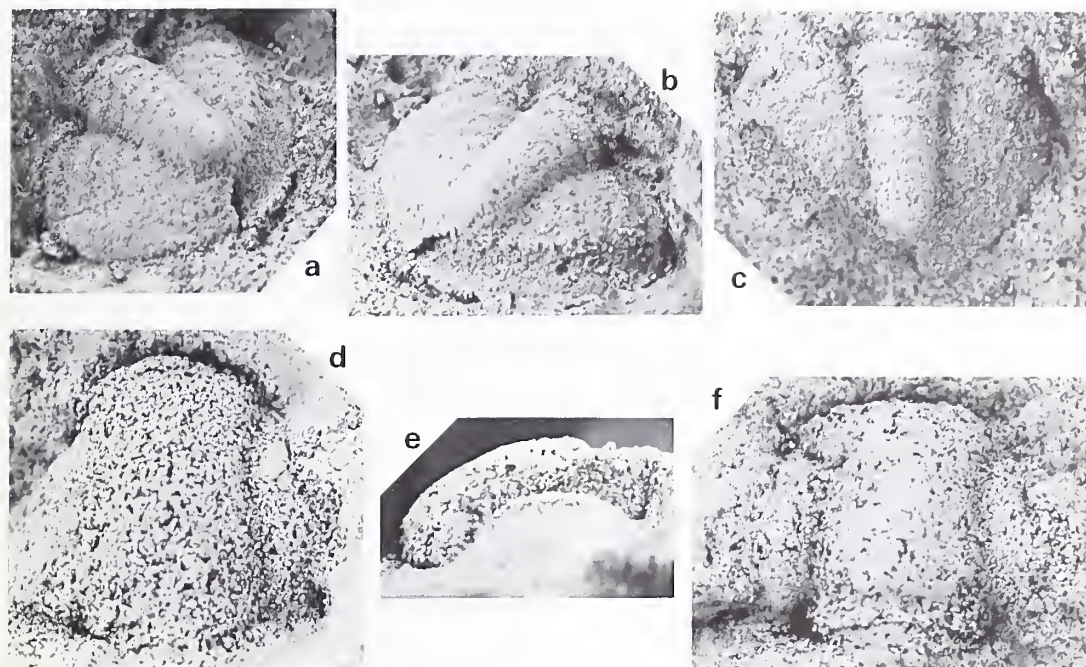


Fig. 7 *Annamitella sinesulcata* sp. nov. All material from Loc. A. a, b: It19840 ($\times 3$), oblique views of internal mould of pygidium. Note flat border and concave doublure. c: It19817a ($\times 5$), internal mould of pygidium. d: It19818 ($\times 5$), internal mould of cranidium. Note anterior border. e, f: **Holotype** It19829 ($\times 5$), internal mould of cranidium, lateral and dorsal views.

profile moderately convex, glabella standing well above fixed cheeks which are at approximately half total height of cranidium. Sagittal profile also convex, glabella curving steadily down from highest point immediately anterior to occipital furrow.

Occipital furrow broad and slightly concave posteriorly, causing axial widening of occipital ring. On exterior of exoskeleton this furrow would probably be narrower and more sharply defined (cf. Fortey & Shergold 1984: pl. 38, figs 3, 5); this is probably also true of the axial furrows.

Apart from the prominent occipital furrow and slight evidence of an anterior border, the glabella is totally effaced, with no indication of lateral glabellar furrows.

Fixed cheeks dominated by elongate, subparallel-sided inflated lobes about a quarter the width of glabella, but expanding inside palpebral lobe to about 0.45 times width of

glabella. Some suggestion exists of depressed areas anterior and posterior to this major ridge on the fixed cheeks, but the form of these not clear.

Palpebral lobes prominent: slightly below level of fixed cheeks from which they are separated by shallow furrow; slightly curved and about a third of width of expanded cheek adaxial to them and about a third total length of cranidium, extending from 0.25 – 0.6 of cranial length (sag.).

Pygidium: Semicircular to slightly triangular in outline with prominent, slightly tapering, subparallel-sided axis and well rounded terminal axial piece. Axial furrows poorly developed, axis standing well above pleural fields and approximately semicircular in transverse section. Articulating half-ring not clear on any specimen. Three to four axial rings and pleural ribs developed, first axial ring much more obvious than others.

Moderately wide flat border of even width (approx. one

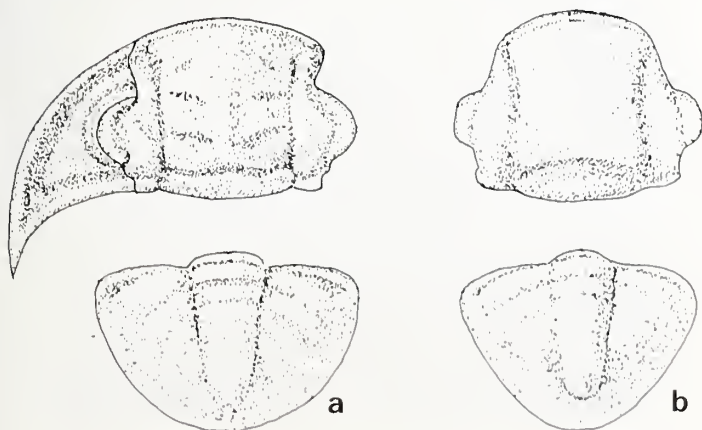


Fig. 8 a, *Annamitella perplexa* (Bates), with free cheek replaced. b, *Annamitella sinesulcata* sp. nov. (Both approx. $\times 3$).

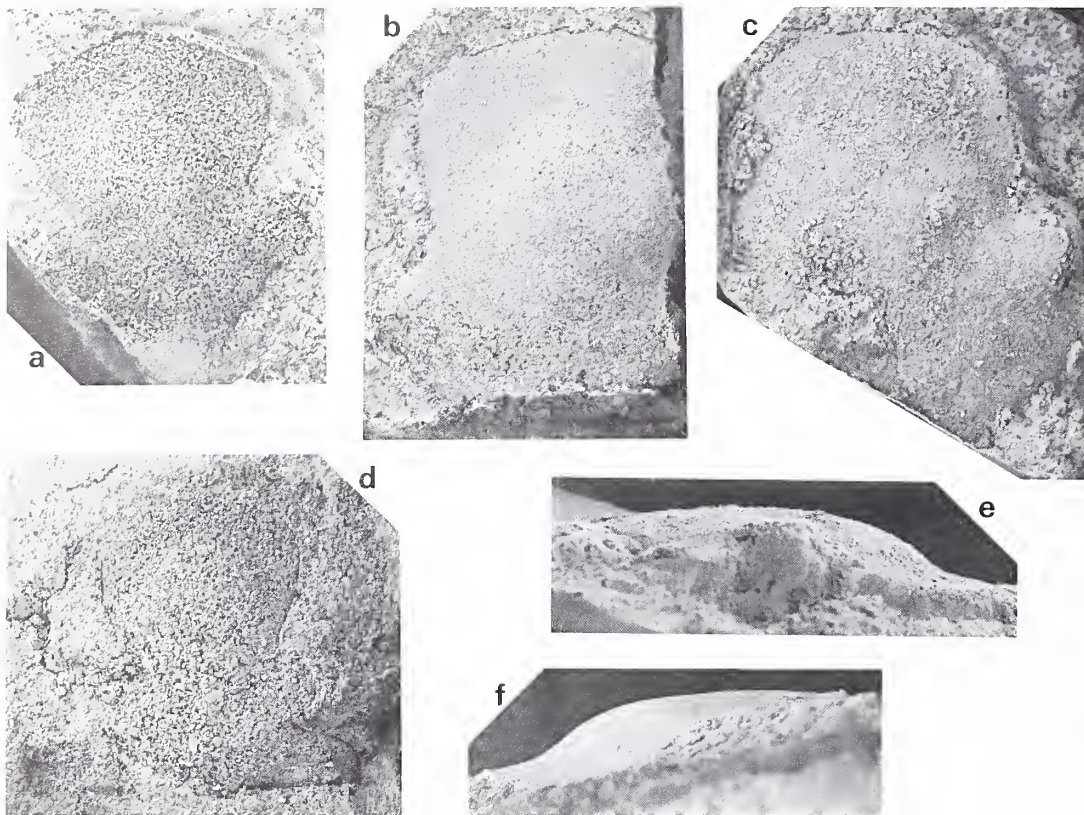


Fig. 9 *Asaphellus* cf. *graffi* (Thoral). All material from Loc.A. a, It19805 ($\times 2$). b, f: It19813d ($\times 2$). c, e: It19813c ($\times 2$). d: It19843 ($\times 2$). All are internal moulds of crania.

quarter length of axis) slopes fairly steeply: axis extends a short distance onto it. Doublure corresponds in position to border and is quite strongly concave on dorsal surface.

DISCUSSION. As noted in discussion of the genus, this species may be separated from all other members of the genus and grouped with *A. perplexa* (Bates) on the basis of the broad, flat pygidial border. It may easily be distinguished from *A. perplexa* by its effaced cranium, a character also not seen in any other members of the genus.

Family **ASAPHIDAE** Burmeister, 1843
Subfamily **ISOTELINAE** Angelin, 1854

Genus **ASAPHELLUS** Callaway, 1877

TYPE SPECIES. *Asaphellus homfrayi* Salter 1866.

REMARKS. Usage follows diagnosis of Fortey & Owens (1987) and their proposed synonymy.

Asaphellus* cf. *graffi (Thoral) Figs 9a-f; 10a-j; 11a-d
cf. 1946 *Plesiomegalaspis graffi* Thoral: 61-68; pl. 6, figs 1 & 2; pl. 8, fig. 1; pl. 9, fig. 1; pl. 10; pl. 11, fig. 3; pl. 12; pl. 13, fig. 1; pl. 14, fig. 1a-b; pl. 15, fig. 4; pl. 16, fig. 4.

MATERIAL. Crania: It19805, It19810, It19813, It19834, It19843, It19848-9, It19857. Pygidia: It19824, It19827, It19842, It19847. Hypostomes: It19820, It19829, It19831, It19836, It19851. Free cheeks: It19803, It19823, It19833, It19838,

It19850. Additional material in National Museum of Wales: 85.16G. 34-43, 85.16G.46.

LOCALITY. Cutting on A5 at Caerhŷn.

DESCRIPTION. Species attaining moderate size: largest cranium is 23 mm wide anteriorly, allowing estimate of cranial length of c. 34 mm, whilst largest free cheek suggests cranial length over 40 mm. Largest pygidium is 45 mm wide anteriorly.

Cranidium. Preocular sutures slightly divergent (range 49° to 22° enclosed angle), angle decreasing with size. Anterior of cranium pointed, anterior sutures enclosing angle of 132° to 145° . Anterior sutures are intramarginal as confirmed by free cheeks (see below).

On one specimen (It19843), 2 cm long (sag.), the eye position can be seen clearly; it is placed well back in the posterior half, the palpebral lobe extending from 0.23 to 0.40 along the sagittal length of cranium. Though not easy to judge exactly from free cheeks it appears that even in larger crania the length posterior to the eye would still be less than 1.5 times the length of the palpebral lobe. In the largest specimen (It19813) the post-palpebral length appears to be 1.35 times the length of palpebral lobe. Palpebral lobe semicircular in outline and only just below maximum elevation of glabella.

Glabella effaced, and slopes gently down on all sides: no axial or preglabellar furrows. Front of glabella slopes down into anterior border which is still slightly sloping but at a lower angle, producing a concave profile to the anterior of cranium. Anterior border widest at anterolateral corners of

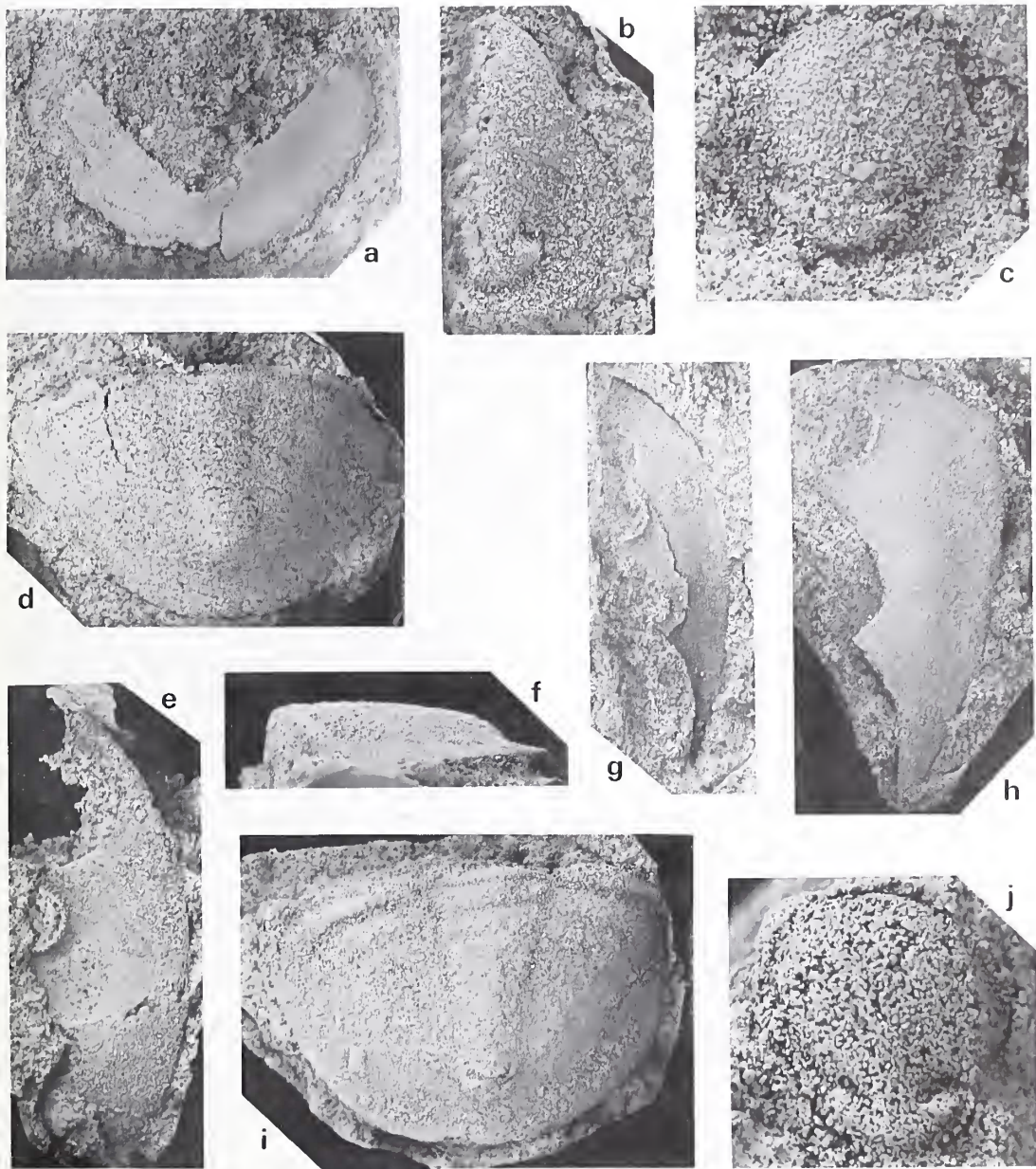


Fig. 10 *Asaphellus* cf. *graffi* (Thoral). All material from Loc. A. a: It19822 ($\times 2$), poor internal mould of pygidium showing doublure. b: It19829 ($\times 3$), latex cast of external mould of broken hypostome. c: It19831 ($\times 7.5$), internal mould of hypostome. d: It19827 ($\times 1.25$), latex cast of external mould of pygidium. e: It19803 ($\times 1.18$), latex cast of external mould of free cheek. f, i: It19824 ($\times 1.25$), latex cast of external mould of pygidium. g: It19838 ($\times 1.25$), internal mould of free cheek. h: It19833 ($\times 1.25$), latex cast of external mould of free cheek. j: It19820 ($\times 7.5$), internal mould of hypostome.

cranium where it reaches one quarter of the maximum preocular width (tr.) of cranium; it narrows towards the midline.

Though poorly preserved there is no evidence of any occipital furrow, and only slight evidence of a posterior border furrow.

Free Cheek. External margin gently curved and extending posteriorly into pronounced genal spine, which becomes broader and more truncate in larger specimens. Preocular and postocular sutures fairly straight for majority of length and strongly curved at their abocular ends. This curve turns the postocular suture through about 90° , to run perpendicular to the immediately adjacent part of genal spine, and thence to

the posterior margin of cranium. Preocular suture curves to become parallel with front margin of cranium, with a thin extension of the dorsal exoskeleton continuing external curvature of the free cheek. The two sutures converge at an angle just less than 90° in plan view, and are of approximately equal length.

In plan view a broad concave border occupies just less than half the maximum width. Doublure is co-extensive and slightly more concave in profile. Terrace lines are faintly developed on the doublure.

A panderian opening is present on It19838 just interior to paradaubular line and close to posterior margin.

Hypostome. Oval in outline, with posterior broader.

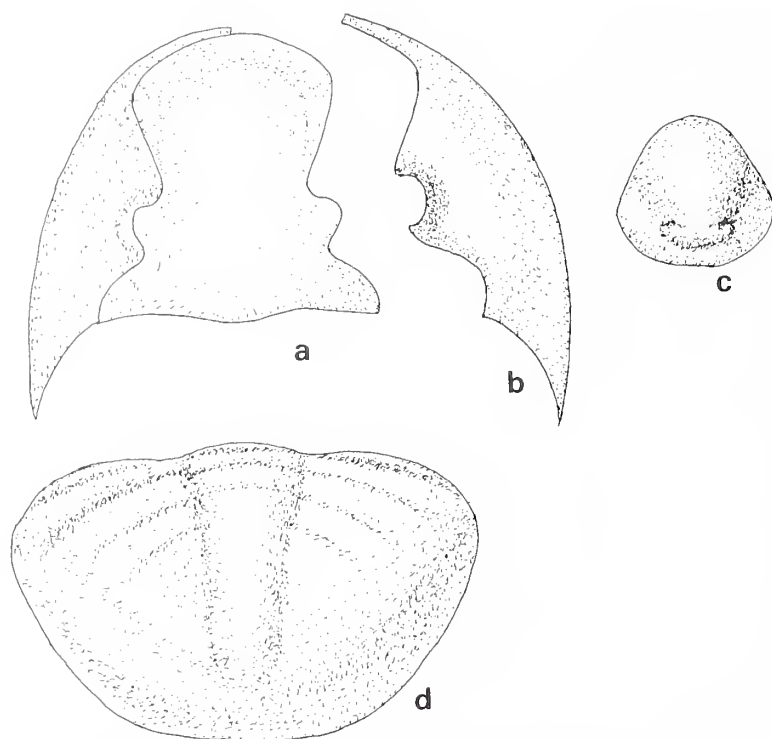


Fig. 11 *Asaphellus* cf. *graffi* (Thoral). a, cranium with free cheek replaced. b, free cheek in plan view. c, hypostome. d, pygidium. (All approx. $\times 1$).

Anterior margin formed by median body; no anterior border preserved. Median body occupies about 0.9 of length (sag.), with posterior lobe one quarter of the length (sag.) of anterior lobe, and separated from it by a pair of prominent maculae. There is little evidence of a border furrow, but the maculae are joined by a slight furrow extending around the rear of the posterior lobe. Overall shape of median body is elliptical.

Prominent lateral border starts at approximately half the length of the anterior lobe, with margin initially straight and tangential to anterior curvature of lobe. Maximum width is opposite maculae. Posterior to this, the margin curves sharply inwards, the border narrowing into posterior border; posterior margin a smooth curve parallel to border furrow of posterior lobe.

Pygidium. Broadly semicircular in outline though slightly straightened postaxially. Length: breadth ratio 1:1.5–1.6 in largest pygidia. Transverse profile strongly convex. Border broad, about one third of the length (sag.) of axis at its widest, and steeply sloping, flat to slightly concave. Narrows postaxially with suggestion of increased concavity.

Axis only slightly inflated with faint axial furrows. Maximum width of axis less than 0.3 of maximum width (tr.) of pygidium, with posterior well rounded and extending a very short distance onto border. At most three axial rings are apparent and a similar number of pleural furrows: only the first of each is clearly defined. Narrow articulating half-ring.

Doublure approximately corresponds to border, and is more strongly concave than border. Narrows postaxially, giving distinct v-shape to interior doublural margin, though details of this are not well preserved.

DISCUSSION. The main problem in comparing the Welsh material with that of *A. graffi* (Thoral) is the generally larger size of the latter. If the larger specimens of the Welsh population are fully mature then this size difference may be a taxonomic difference in itself, but may alternatively reflect ecophenotypic variation. There is a small difference between

the two populations in the development of the genal spines. These become blunter in larger specimens of both populations, but in the case of the type material of *graffi* the spine is still pointed in specimens with a cranial length of 45 mm; Welsh specimens of this size already have blunt spines. There are a number of other minor differences that can be recognized.

(1) The eye in the Welsh specimens is more posterior in position. The eye in *A. graffi* is positioned at between about 0.3 and 0.5 of the cranial length (sag.), whilst that of the Welsh specimens is between 0.2 and 0.4.

(2) The line of the postocular suture has a much sharper curvature in *A. cf. graffi*.

(3) The pygidial border appears to narrow postaxially in *A. cf. graffi* whilst of constant width in *A. graffi*. The ratio of the postaxial length against axial length is less than 0.25 in the Welsh specimens, and greater than this in the French specimens, but evidence is limited to two and three specimens respectively.

(4) The posterior margin of the posterior lobe of the hypostome is smoothly rounded in the Welsh specimens whilst there is a distinct pointed posterior axial extension to the lobe in *A. graffi*.

The asaphid described from the Carmel formation on Anglesey (Bates 1968: pl. 12, figs 1–6) has more divergent preocular sutures and a centrally placed eye. *A. whittardi* (Bates 1969) has a much more strongly furrowed pygidium (Whittard 1964: pl. 38, figs 10–13). The specimens figured as *A. graffi* by Gigout (1951: pl. 2, figs 1–5) from Morocco are probably better referred to *A. whittardi* than to *A. graffi*.

Family **CALYMENIDAE** Burmeister, 1843
Subfamily **REEDOCALYMENINAE** Hupé, 1955

Genus **NESEURETUS** Hicks, 1873

TYPE SPECIES. *Calymene parvifrons* var. *murchisoni* Salter, 1865.

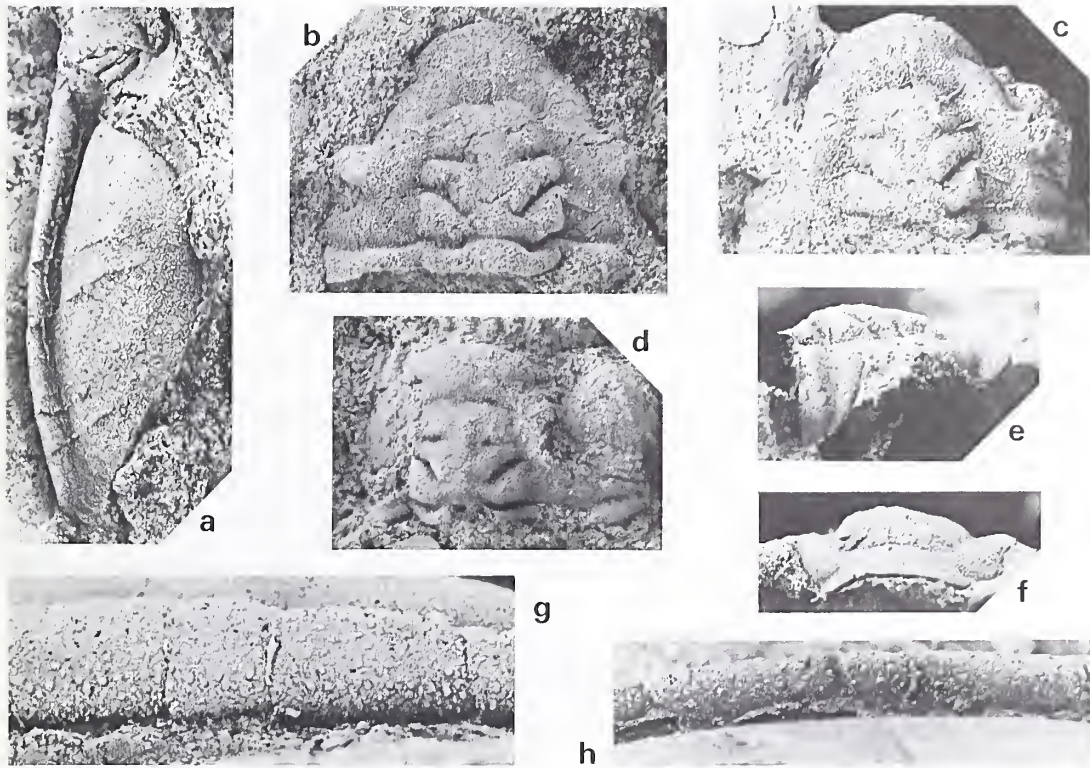


Fig. 12 *Neseuretus monensis* (Shirley). All material from Carmel Formation, central Anglesey; British Geological Survey colln. a; Af.831 ($\times 2.5$), internal mould of free cheek. b: Af.832 ($\times 2.5$), holotype; latex cast of external mould of cranidium. c, e, f: Af.831 ($\times 2.5$), holotype; internal mould of cranidium. d: Af.830 ($\times 3$), internal mould of cranidium. g: Af.831 ($\times 7.5$), ornament on underside of doublure of free cheek. h: Af.831 ($\times 7.5$), ornament on border of free cheek.

***Neseuretus monensis* (Shirley 1936)** Figs 12a–h

- 1919 *Neseuretus parvifrons* Salter; Greenly : 442, 446.
 1936 *Synhomalonotus monensis* Shirley: 401–402; pl. 30, figs 1–4.
 1968 *Neseuretus monensis* (Shirley) Bates : 193; pl. 14, figs 11, 16.

DIAGNOSIS. *Neseuretus* with oblique eye ridges, moderately long (sag.) anterior area 0.45 to 0.61 times preoccipital length (sag.) of glabella. No anterior furrow or border visible.

HOLOTYPE. British Geological Survey colln Af831–2. Internal and external moulds of isolated cranidium.

MATERIAL. Cranidia: Af830–2, Af1404, 56372. Free Cheek: Af831. All B.G.S. colln.

LOCALITY & OCCURRENCE. Carmel Formation, central Anglesey.

DESCRIPTION. **Cranidium.** Four specimens were examined, including the holotype and another specimen (Af830) figured by Shirley (1936). Apart from the holotype, only internal moulds are preserved. The holotype is probably deformed; it is extensively cracked and if complete the right free cheek would be completely obscured in plan view whilst the left would be well exposed. Hence the furrows are probably overdeepened. It was probably deformed by compression in the plane of the specimen, perpendicular to the axis. Specimen Af830 is probably the least deformed of the material examined.

Cranidium outline is trapezoidal, the triangular form noted by Shirley being based on the deformed holotype. Glabella has trapezoid outline, and stands well above palpebral lobes.

Two prominent lateral furrows: 1P with typical posterior inclination, 2P perpendicular to axis. Faint 3P furrow present on Af830 and visible on left side of external mould of holotype. Occipital furrow curves forwards at the axis, causing a narrowing of the 1P lobe. Lateral furrows shallow, expanding into crescent-shaped depressed areas posteriorly, anterior margins of which are approximately level with 1P furrow. Preglabellar furrow moderately deep, with fossulae developed approximately at intersection with axial furrows. Eye ridges oblique; cross axial furrows just posterior to fossulae; enclose angle posteriorly of c.140°. Palpebral lobes posteriorly positioned. Line joining posterior edges crosses glabella at exterior end of 1P furrow, that for anterior at exterior end of 2P furrow. As noted by Shirley, this places the palpebral lobe opposite 2P lobe. Palpebral lobes separated from axial furrows by 0.4 of glabellar width, as measured between them.

Anterior area gently domed posteriorly, before curving down smoothly to anterior margin. No anterior border or furrow. Anterior margin curves under inflated fixed cheeks which cut into anterior area at approximately half its length (sag.). Ratio of length of anterior area (sag.) to preoccipital length of glabella (sag.) ranges 0.4–0.6.

Free Cheek. One deformed specimen known. Prominent border, exaggerated by deformation, separated by overdeepened furrow. Fine tuberculate ornament both on upper surface and on under doublural surface. Sutures intersect at approx 100°. Postocular suture 1.7 times as long as preocular.

Pygidium. No material additional to that described by Bates (1968) is available.

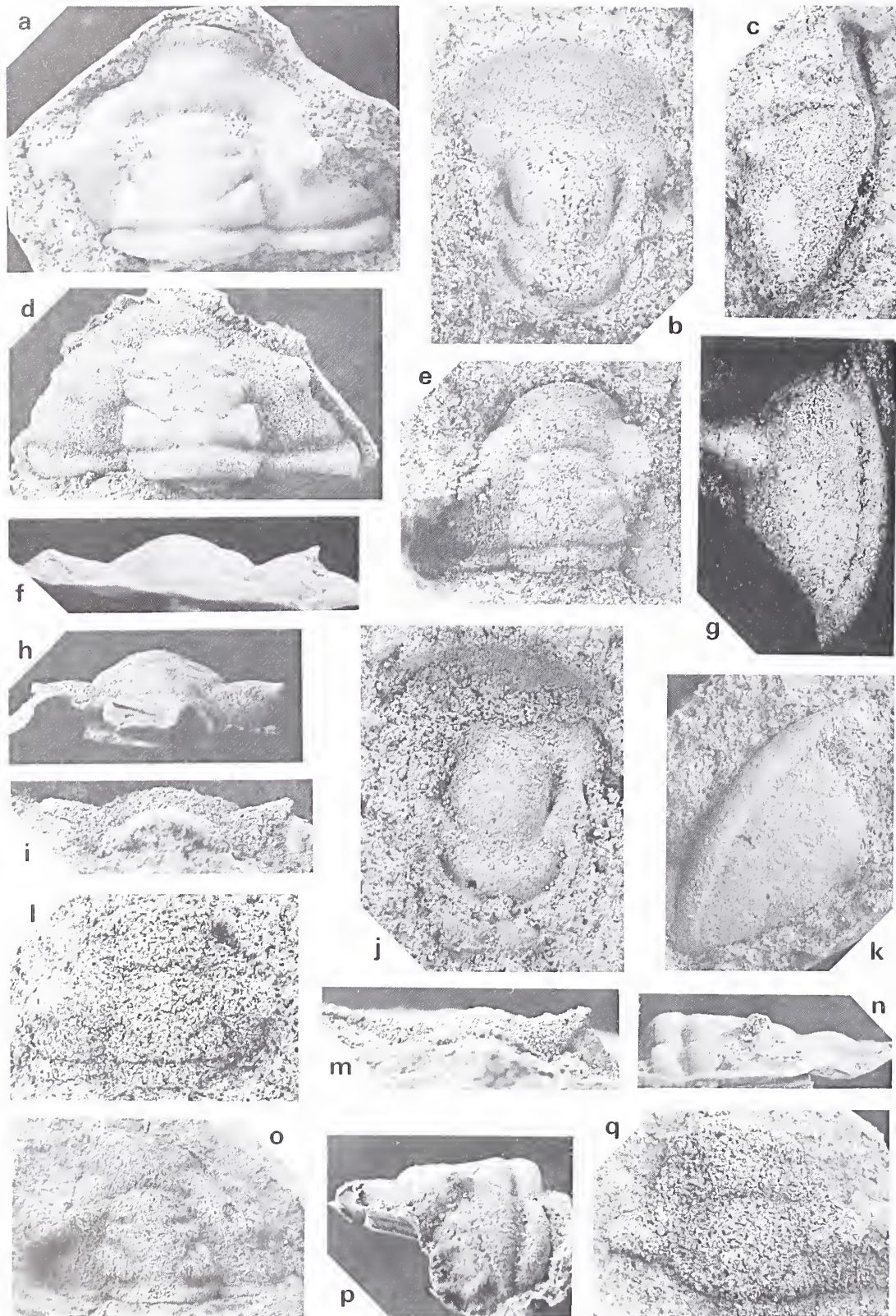


Fig. 13 *Neseuretus caerhunensis* sp. nov. All material from Loc. A. a, f, n: **Holotype** It19800 ($\times 2$), latex cast of external mould of cranium. b: It19811 ($\times 5$), latex of external mould of hypostome. c: It19809 ($\times 2$), internal mould of free cheek. d, h, p: It19839 ($\times 2$), latex cast of external mould of cranium. e: It19813 ($\times 2$), internal mould of cranium. g: It19803 ($\times 2.5$), latex cast of external mould of free cheek. i, q: It19804 ($\times 3$), latex cast of external mould of cranium. j: It19811 ($\times 5$), internal mould of hypostome. k: It19803 ($\times 2.5$), latex cast of external mould of free cheek. l, m: It19806 ($\times 5$), latex cast of external mould of free cheek. o: It19835 ($\times 2$), internal mould of cranium.

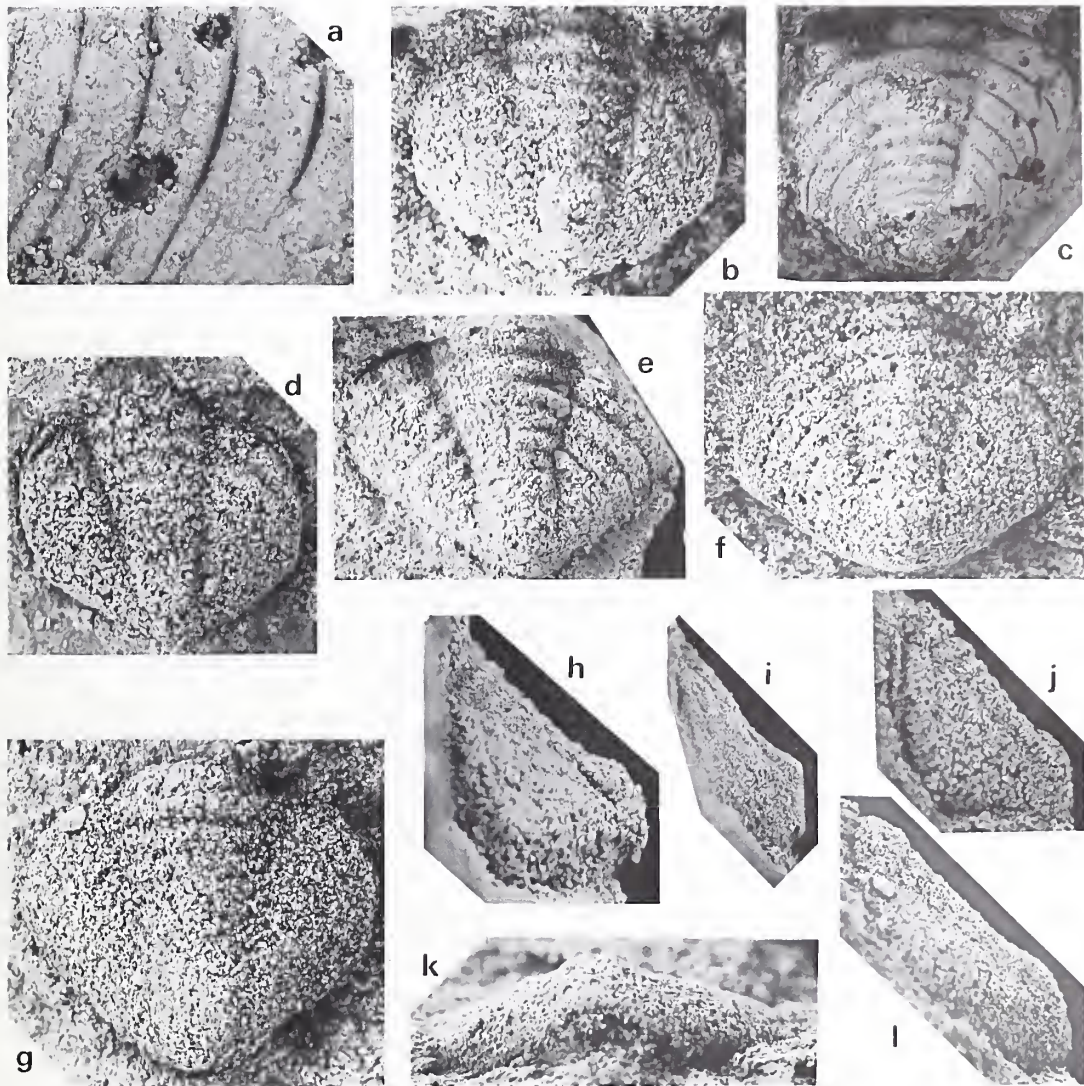


Fig. 14 *Neseuretus caerhunensis* sp. nov. All material from Loc. A. a: It19807 ($\times 7.5$), detail of ornament on internal mould of pygidium, lateral view. b, h: It19832 ($\times 5$), internal mould of pygidium. c: It19807 ($\times 2.5$), internal mould of pygidium. Note constrictions on lateral parts of axial rings. d, j: It19805 ($\times 5$), internal mould of pygidium. e: It19828 ($\times 3$), internal mould of pygidium. f, k: It19808 ($\times 5$), internal mould of pygidium. g, l: It19830 ($\times 5$), latex cast of external mould of pygidium. i: It19801 ($\times 3$), internal mould of pygidium.

DISCUSSION. See under *Neseuretus caerhunensis*.

Neseuretus caerhunensis sp. nov. Figs 14a–l; 15a–d

DIAGNOSIS. *Neseuretus* species with distinctly oblique trend of eye ridges and long (sag.) anterior area (more than 0.62 of preoccipital glabella length (sag.)). Anterior border furrow slightly developed, marking off approximately horizontal border. Hypostome has distinct anterior and posterior lobes of the median body, the posterior lobe crossing the border furrow into an inflated anterior part of the lateral border. Posterior of hypostome smoothly rounded.

HOLOTYPE. It19800. Well-preserved cranidium.

OTHER MATERIAL. Cranidia: It19804, It19806, It19813, It19819, It19835, It19839, It19842, It19845, It19854. Pygidia: It19801, It19805, It19807–8, It19828, It19830, It19832. Hypostomes: It19811, It19853. Free cheeks: It19803, It19809,

It19816, It19825, It19852, It19856–7. Additional material in National Museum of Wales: 85.16G.51–63.

LOCALITY & OCCURRENCE. Only known from type locality, the A5 cutting at Caerhŷn. An indeterminable *Neseuretus* (N.M.W. 85.16G.47) from the Bangor foreshore is likely to be this species.

NAME. After village near type locality.

DESCRIPTION. Cranidium. A number of cranidia are known, ranging in size up to 30 mm wide (tr.) and 18 mm long (sag.), the two best-preserved being of the maximum size: the description is based mainly on these. Cranidial shape is approximately sub-trapezoidal, with significantly rounded anterior, preocular sutures converging slightly, but anterior width (tr.) remaining greater than posterior width (tr.) of glabella.

Glabella is approximately trapezoidal and moderately inflated, well defined by axial and preglabellar furrows. Three

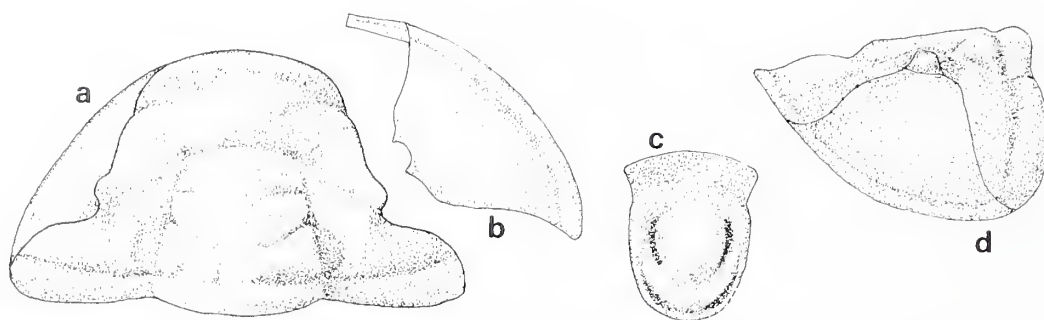


Fig. 15 *Neseuretus caerhunensis* sp. nov. a, cranidium with free cheek replaced. b, plan view of free cheek. c, hypostome. d, reconstruction of lateral view of cephalon. (All approx. $\times 2$).

pairs of lateral glabellar furrows are present. The 1P furrow trends backwards towards the sagittal line and forms an angle of c. 50° with it. At its inner termination this furrow turns perpendicular to the sagittal line and may even be inclined slightly anteriorly in some cases. A fifth of glabellar width (tr.) is not cut by this pair of furrows. 2P furrow straight and approximately perpendicular to the sagittal line. On the holotype it is perched but this does not appear to be normal. The 3P furrow is very faint, but can be seen on the holotype and lies approximately midway between the 2P furrow and anterior of glabella. Axial ridge, apparent on well-preserved specimens, broadens and merges with anterior lobe. The 1P lobe narrows considerably adaxially, whilst the 2P expands adaxially by a compensating amount.

Occipital furrow is approximately straight and fairly evenly developed apart from slight fading over mid-axis. There appears to be a constriction of the furrow on either side of the glabella. In one specimen the axial part of furrow has a slight anterior curvature. Axial furrows expanded into a crescentic depressed area posterior to the palpebral lobe, and anterior to this area they are only slightly developed. Preglabellar furrow moderately well developed with fossulae present at its junction with axial furrows.

Palpebral lobes prominent: line joining their posterior margins crosses the glabella at, or just anterior to, the 1P furrow. They are separated from the glabella by half the glabellar width, as measured along the same line. Line joining anterior margins of palpebral lobes runs just posterior to 3P furrow. Eye ridges trend anteriorly from palpebral lobes, the pair enclosing an angle of 144° – 154° , and cross the axial furrow just posterior to fossulae.

Anterior area (anterior border plus preglabellar field) large, ranging in length (sag.) from 0.6–0.8 of preoccipital length of glabella. Though posterior part of preglabellar field is somewhat domed, preocular fixed cheeks are more raised, producing appearance of slight furrows diverging anteriorly. Anterior border furrow moderately developed with anterior border horizontal in profile.

Free Cheek. In plan view the two sutures converge at about 90° , the preocular suture length being two-thirds of the postocular. A moderately inflated border is present, which occupies a quarter of the width opposite the eye. The border widens a little posteriorly whilst the doublure narrows, as it is turned to a higher angle relative to the plan view. No sculpture is seen on border, though this may reflect mode of preservation. A significant length of doublure extends from the front of the free cheek, confirming the wide separation of the anterior sutures.

Hypostome. Only one complete specimen is known, which is 9 mm long; it is represented by both internal and external moulds. A depressed anterior area, typical of the *Neseuretus* hypostome, is well developed, occupying just less than one third of the total length (sag.). The median body is divided into distinct anterior and posterior lobes, separated by a crescent-shaped depression. The anterior lobe is oval, narrower end posterior, with each end grading down into the depressed areas, and laterally bordered by deep furrows. Posterior lobe is crescent-shaped, its posterior edge steeper than anterior. This lobe extends across the line of the border furrow, dividing it in two and causing an inflated portion of the lateral border alongside the anterior lobe. Border furrow behind posterior lobe follows curvature of the latter, before it is truncated by extension of the posterior lobe. There is some suggestion of deepening at anterior ends, though depth of the posterior border furrow appears more even on the internal mould. Anterior part of border furrow becomes shallower posteriorly, grading into the depressed area separating the two lobes of median body. Posterior margin of hypostome smooth, and follows curvature of posterior border furrow. Posterior border narrow. Lateral border continuous with posterior border and merges with extension of posterior lobe into a broader and more elevated anterior portion, which curves down gently to the lateral margin.

Pygidium. Pygidia assigned to this species fall into two size groupings: greater and less than 10 mm in length (sag.). Two well-preserved specimens of the larger size have different outlines, one being distinctly triangular whilst the other is well rounded posteriorly. Both have a funnel-shaped axis, the axial furrows converging at 35° until just posterior of the fifth axial ring, and thereafter continuing subparallel. Nine axial rings are present on one specimen and show slight constrictions forming small tubercular inflations at their lateral terminations. On the other specimen only six axial furrows are apparent, with no evidence of the tubercular terminations; this may reflect coarser preservation. Posterior of axis inflated in sagittal profile. Six pleural furrows present on better-preserved specimen, short interpleural furrows being developed in the steeply down-turned sides of the pleural field. A fine tuberculate sculpture covers the pygidium.

The smaller pygidia are grouped with this species on the posterior inflation of the axis. However, they differ from the larger specimens in being somewhat effaced, with axial furrows only shallowly developed and fading posteriorly, and with three to four axial and pleural furrows indistinctly developed. A prominent articulating half ring which is longer (sag.) than first axial ring is present in two specimens.

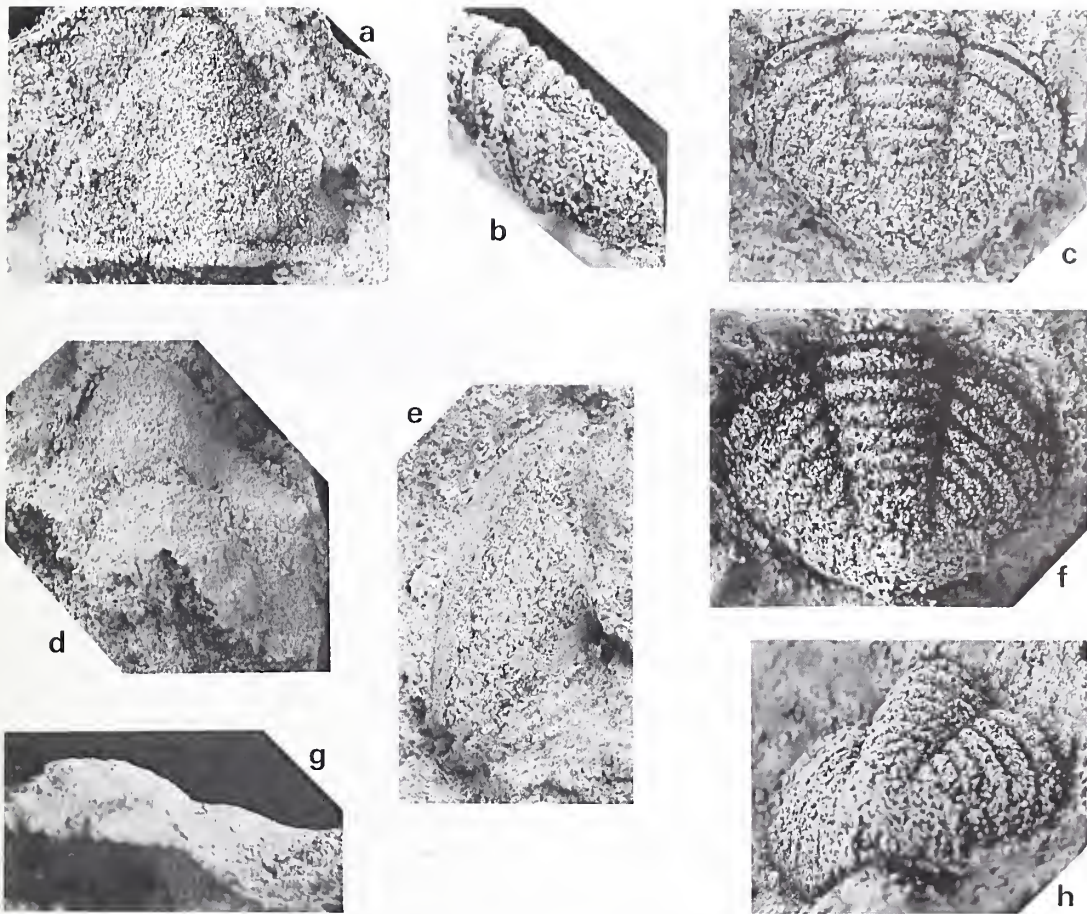


Fig. 16 *Calymenella preboiselli* sp. nov. All material from Loc. A except specimen It19844 (g) which comes from Loc. B. a: **Holotype** It19812 ($\times 3$), latex cast of external mould of cranium. b, c: It19817 ($\times 5$), internal mould of pygidium. d, g: It19844 ($\times 2.5$), internal mould of cranium. e: It19826 ($\times 3$), internal mould of free cheek. f, h: It19815 ($\times 5$), internal mould of pygidium.

This character is not preserved in either of the larger specimens.

DISCUSSION. Since the various skeletal elements described under the above species are derived from an assemblage of disarticulated fragments, there is no direct evidence that they all belong to the same species. However, this is only questionable for the pygidia and these have been separated into two groups on the presence or absence of the posterior inflation of the axis, those not showing this being assigned to *Calymenella preboiselli* (p. 18). The development of a postaxial ridge, considered characteristic of *Neseuretus* (Hammann 1983: 40, fig. 17), is seen in two of the pygidia (e.g. his pl. 24, fig. 2) and the posterior inflation of the axis is also shown by other members of the genus (e.g. *N. parvifrons* (M^cCoy) Whittington 1966: pl. 4, fig. 12).

In only four other species of *Neseuretus* has the hypostome been described: *N. parvifrons* (M^cCoy) (Bates 1969: 26; pl. 9, figs 4, 10; Whittington 1966: 501–2; pl. 5, figs 5, 8); *N. tristani* (Brongniart) (Henry 1980: pl. 10, figs 4a–b, pl. 11, figs 2, 5; Hammann 1983: pl. 6, figs 61, 64); *N. avus* Hammann (Hammann 1983: pl. 4, fig. 46) and *N. henkei* Hammann (Hammann 1983: pl. 7, fig. 74). Henry (1980) considers that there is considerable intraspecific variation in the form of the hypostome (1980: 71, fig. 25), but since each of his specimens comes from a different locality it seems more likely that the

variation may be indicative of subspecies, as recognized by Hammann (1983). This would therefore suggest that the hypostome includes significant taxonomic features, limited in usefulness by its rare preservation.

The hypostome described above is quite distinct from those previously described in that the border furrow is not continuous. However, there is some similarity to that of *N. parvifrons*, in the form of the anterior and posterior lobes, and the hypostome of *Neseuretus caerhunensis* could easily be derived from this by the extension of the posterior lobe. There is no evidence of the maculae seen in *N. tristani*.

The form of the lateral glabellar furrows, in which there is a marked adaxial divergence of 1P and 2P, with the 2P furrow approximately perpendicular to the sagittal line, may be considered typical of *Neseuretus* as it is also seen in the type species *N. nurchisoni* (Salter 1865). This, associated with the oblique form of the eye ridges, which are more normally perpendicular to the sagittal line (cf. Whittard 1960: pls 19, 20), separates the new species, along with *N. monensis* (Shirley 1936: 401–2; pl. 29, figs 1–4), from other members of the genus. The oblique form of the eye ridge results from the posterior position of the eye, approximately opposite the 2P lobe, a feature Shirley (1936: 402) noted as being diagnostic of *N. monensis*. The Bangor species is easily distinguished from *N. monensis* in having a longer anterior area and obvious anterior border.

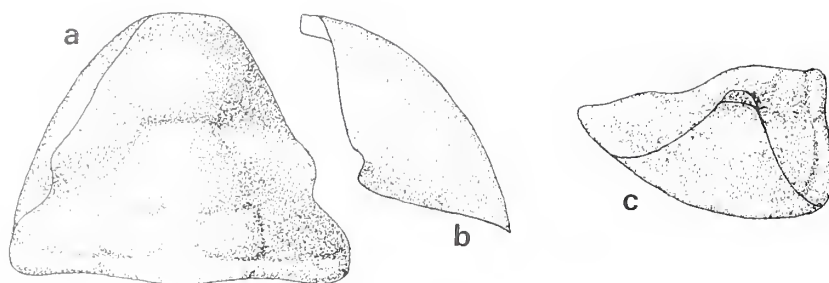


Fig. 17 *Calymenella preboiselli* sp. nov. a, cranidium with free cheek replaced. b, free cheek in plan view. c, lateral view of reconstructed cephalon. (All approx. $\times 3$).

Genus *CALYMENELLA* Bergeron, 1890

TYPE SPECIES. *Calymenella boisselli* Bergeron, 1890.

Calymenella preboiselli sp. nov. Figs 16a–h; 17a–c

DIAGNOSIS. *Calymenella* very similar to type species in having elongate sub-triangular anterior area, but differing from this and other species in having less strongly developed lateral, preglabellar and occipital furrows. Glabella is of a rounded pentagonal form. Posterior part of pygidial axis is ill-defined.

HOLOTYPE. It19812. Cranidium.

MATERIAL. Cranidia: It19802, It19812, It19821, It19834, It19844. Pygidia: It19815, It19817. Free cheeks: It19803, It19826, It19832, It19837, It19855.

LOCALITY & OCCURRENCE. Cutting on A5 at Caerhŷn, with a single specimen (It19844) from the foreshore at Bangor.

NAME. From close similarity to type species but occurring much earlier.

DESCRIPTION. **Cranidium.** Three well-preserved specimens known, all about 15 mm long. Poorly preserved specimens are difficult to distinguish reliably from the *Neseuretus* in the fauna. Cranidium strongly triangular, with slightly truncated, rounded anterior. Glabella occupies approximately three-fifths of preoccipital length (sag.) of cranidium and has rounded, sub-pentagonal outline. At least two pairs of shallow and broad, indistinctly developed lateral furrows are present, with 1P lobe moderately well defined. 1P furrow inclined gently backwards, causing 1P lobe to narrow adaxially. 1P furrow also slightly curved, being approximately perpendicular to axis at inner termination. Axial unfurrowed area present, of approximately same width as shallower portion of occipital furrow. 2P furrow very poorly defined and little more than a shallow depressed area, the orientation of which is unclear, but appears to be elongate perpendicular to axis. Axial and preglabellar furrows poorly developed. Absence of marked furrows means glabella is less well defined in plan view than is apparent from profile view. Palpebral lobes quite large, posterior margin approximately level with 1P furrow, and anterior margin only slightly behind anterior of glabella. Eye ridge present; inclined slightly forward towards sagittal line.

Preocular sutures straight in dorsal view and converge sharply towards anterior enclosing angle of 65° . Preglabellar field elevated just anterior to preglabellar furrow, and then sloping down with concave curvature into ill-defined anterior border, hardly apparent in dorsal view. Anterior of cranidium narrower than posterior width of glabella. Occipital furrow deepest at margins of glabella, fading over the axis and curving slightly forwards. Posterior border furrow well

developed, curving slightly forwards abaxially. Occipital ring well-defined laterally but almost merges into preoccipital portion of glabella at axis. Posterior border widens laterally as result of anterior curvature of posterior border furrow.

Free Cheek. In plan view sutures converge at about 120° . Preocular suture slightly longer than postocular. Genal angle rounded. Doublure just under a quarter the width of free cheek opposite eye, and in plan view narrows towards genal angle apparently as result of being more steeply inclined to surface of free cheek. Slightly elevated border on dorsal surface approximately same width as doublure.

Pygidium. Both pygidia assigned to this species are known only from internal moulds, the external that exists for one being too poor to warrant description. Both are small, 6–7 mm long (sag.), approximately 1.25 times as wide as long and rounded posteriorly. Axis occupies one third of maximum width anteriorly and tapers posteriorly, margins defined by prominent axial furrows that converge to enclose angle of 20° . Six or seven axial rings present.

There are five or six pleural furrows; no interpleural furrows have been observed though this may result from coarse preservation. Posterior of axis ill-defined and appears to grade into the postaxial area: this is supported by the lateral profile which shows an almost continuous curvature between the two.

Articulating half-ring narrow.

DISCUSSION. The pygidia assigned to this species are distinguished from those of the *Neseuretus* by the absence of a posterior inflation of the axis and the more prominent axial and pleural furrows in specimens of equivalent size.

Calymenella has previously been considered restricted to the Caradoc and ?Ashgill (Hammann 1983: 72) and therefore the material described here represents a significant extension of the range. In view of this it is remarkable that the north Wales species bears so close a resemblance to the type species of the genus, *C. boisselli* Bergeron, from which it differs mainly in its cephalic effacement.

The only other species that shows a comparable convergence of the preocular sutures is *C. alcantarae* Hammann & Henry 1978, but in both this and the type species the palpebral lobe is smaller than in the Welsh specimens, which accordingly have oblique eye ridges. In addition the furrows bounding the glabella tend to be more prominent in *C. alcantarae*.

The posterior of the pygidial axis is less clearly defined than is typical of the genus (see Hammann 1983: 38, fig. 16).

Calymenella sp. A

Figs 18a–c

MATERIAL. It19814. External mould of cranidium.

LOCALITY. Cutting on A5 at Caerhŷn.

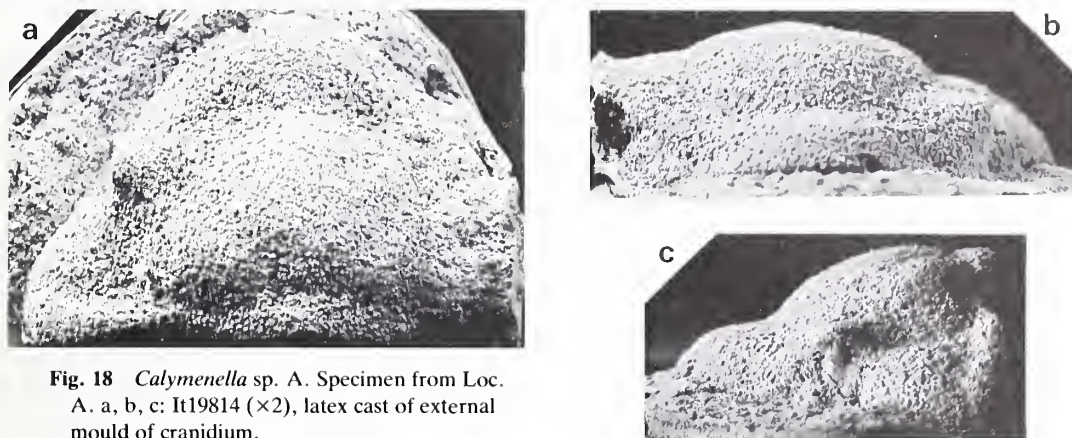


Fig. 18 *Calymenella* sp. A. Specimen from Loc. A. a, b, c: It19814 ($\times 2$), latex cast of external mould of cranium.

DESCRIPTION. Dimensions of the single cranium known: 22 mm long (sag.), 34 mm wide (tr.) and 13 mm high.

Outline of cranium well rounded, semicircular to slightly triangular. Glabella outline similar to that of cranium, highly domed; it occupies half the total height of the cranium. Maximum elevation is just anterior to occipital furrow and in profile curves down smoothly to anterior. Glabella featureless except for occipital furrow and faint 1P furrow that forms an approximately straight depression from axial posterior of glabella to palpebral lobe, and separates off the somewhat inflated 1P lobe. Occipital ring widens axially and is poorly developed behind 1P lobes.

Preglabellar field 0.29 of total cranial length (sag.) and approximately half preoccipital length (sag.) of glabella. Neither preglabellar nor axial furrows clearly developed, the margins of the glabella marked by sharp changes of slope. Posterior two-thirds of preglabellar field slopes gently downwards whilst anterior third is sharply curved down. The gently sloping area appears to narrow slightly as it curves towards the palpebral lobes, whilst the steeply sloping portion remains approximately the same width when viewed dorsally.

Palpebral lobe only slightly separated from glabella and in profile is approximately level with the base of glabella. It lies just over half way along the sagittal line of the cranium, i.e. at between 0.49 and 0.59, and is only slightly elevated above the fixed cheeks. Posterior to palpebral lobe is a gently sloping area of the fixed cheek, widening posteriorly. Posterior border furrow only faintly developed though posterior border is quite strongly inflated and widens quite significantly abaxially.

In lateral view the facial sutures indicate a relatively small free cheek, the preocular suture not extending anterior of the glabella.

DISCUSSION. The generic placement of this specimen has proved difficult. It is included in *Calymenella* because, although a single cranium is inadequate basis for the erection of a new genus, it bears a slight resemblance to *C. bayani* (Tromelin & Lebesconte) (cf. Hammann & Henry 1978: 407, fig. 2). In plan view the specimen also bears some resemblance to *Platycorophe heberti* (Lebesconte) (see Henry 1980: pl. 15, fig. 1), but *Platycorophe* belongs to the Homalonotidae and there is no suggestion in the north Wales specimen of the concave lateral margin of the 1P lobe typical of this family.

AGE AND PALAEOGEOGRAPHIC IMPLICATIONS

The Bangor trilobite fauna provides no independent evidence on the exact age of the Maes y Geirchen Member within the Arenig Series. It is uncertain which Arenig Stage yielded the type material of *A. graffi* in the Montagne Noire, but it is reputed to be 'mid-Arenig'. Consequently *Azygograptus eivionicus* Elles, which occurs in the overlying 'flaggy' sandstone sequence on the Bangor foreshore (Elles 1922) provides the best control on the age. A review of this genus (Beckly 1985) has shown that *A. eivionicus* is characteristic of the Moridunian and may extend into the early Whitlandian. A *Neseuretus* community fauna of Moridunian age is known from the Henllan Ash Member of the Arenig area, north Wales (Whittington 1966), and contains species known also from south Wales (Fortey & Owens 1978). There seems no reason to suppose this fauna was incapable of colonizing the Bangor area, and age equivalence is perhaps unlikely. An early Whitlandian age is perhaps more probable.

An alternative argument could be that the Bangor fauna is Moridunian in age and the differences from the Henllan Member fauna are the result of 'provincial' isolation. Despite there being no species in common, there is clearly a close relationship between the fauna of the Bangor area and that from the Carmel Formation of Anglesey. The small differences that there are may be accounted for by an age difference, the Anglesey fauna probably being Fennian.

One result of the close similarity between the Bangor and Anglesey faunas is that Anglesey can no longer be viewed in isolation from the rest of north Wales, as has been the tendency in the past (Neuman 1984), and any provincial separation would have to be further east. Gibbons (1985) and Reedman *et al.* (1984) have summarized the geological evidence for an Anglesey-like 'terrane' having been near the Welsh Basin during the Lower Palaeozoic. The emphasis here will be on the faunal evidence that exists for the Arenig.

In the south-west of the Llŷn, around Aberdaron, rocks yielding a Moridunian fauna rest on the Mona Complex (Beckly 1985). The fauna includes *Merlinia sebwynii* (Salter), an aphid widespread throughout Wales (Fortey & Owens

1978), and the Gondwanan trinucleid *Hanchungolithus primitivus* (Born) recorded for the first time in the U.K. There is no evidence here of any isolation from the Welsh Basin, though the environment may have been slightly deeper than was typical of the *Neseuretus* community.

An alternative to 'provincial' separation is an environmental isolation, because the *Neseuretus* community environment may have been transient in a marginal setting. Such an environment existed at different places along the western margin of the Welsh Basin in all three stages of the Arenig. By the end of the Arenig the deep-water isograptid biofacies (Beckly 1987), typical of a marginal setting (Fortey & Cocks 1986), was present in the same area indicating the extremely rapid foundering that took place. Close facies association has already been noted in *Neseuretus* during the Arenig (Fortey & Owens 1987), and this is possibly the most likely explanation for the endemism.

The extent of the endemism of the Anglesey and Bangor faunas will be open to some question until faunas of the same facies and age have been reliably recognized elsewhere. However, the Bangor fauna is important in that Anglesey can no longer be considered in isolation from the Welsh mainland, and any major separation seems less likely.

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